

## THE MACROBENTHOS OF SERPENTINE CREEK

W. STEPHENSON  
Department of Zoology, University of Queensland  
and  
B. M. CAMPBELL  
Queensland Museum

### ABSTRACT

Fourteen transects were sampled for macrobenthos in a habitat of small mangrove-fringed creeks at five periods from August 1972 to November 1973, using an 0.05 m<sup>2</sup> van Veen grab and 1 mm mesh sieves.

Data on depths, sediments, salinity, and water temperature were obtained. These abiotic data showed marked temporal variation but indicated coarser sediments in midstream sites and those near the mouths of the estuaries. The most offshore sites showed a salinity range of ca 26‰ to 35‰ and the most upstream sites a range of ca 6‰ to 27‰.

Much of the biota can not be identified to the specific level, reflecting the scant attention given to small estuarine systems on the eastern coast of Australia. Ninety-eight taxa were recorded, about half the number present in the adjacent Bramble Bay, and less than a quarter the number from other parts of Moreton Bay.

Recordings of species in samples were highly skewed and most data were transformed using  $\log_{10}(N + 1)$ . Even after this there was a high proportion of species with 'patchy' high recordings.

From the three dimensional data of species  $\times$  sites  $\times$  times, by summation, two dimensional matrices of species  $\times$  sites and species  $\times$  times were derived. Using the classificatory technique of Stephenson, Cook and Raphael (1977) site-groups and their conforming species were derived. Seven such groups were accepted, indicating fairly small scale topographic patterning, and this made conceptual sense in terms of abiotic data. Site-groups at the upper and lower portions of the sampled area showed the noticeably high population densities and low diversities regarded as characteristic of estuarine biotas.

Classification of species  $\times$  times results did not produce conceptual sense and it is suggested that intervals between sampling were too long. Nevertheless noteworthy fluctuations in the populations of several species were documented.

Attempts are made to describe species in an ecological terminology developed from temperate experience, but problems over the temporal heterogeneity of non-estuarine situations in local waters suggest that caution is required. Of the commoner species *Apseudes estuarius* is the dominant species in all site-groups except those in or close to Bramble Bay, and approximates to an estuarine endemic species. While *Spisula trigonella* appears as an estuarine endemic on the present data elsewhere it acts as an euryhaline opportunistic species. *Xenophthalmus pinnotheroides* approximates to an euryhaline opportunist.

The present work is an analysis of a study (Campbell, Wallace, and King 1976) which was part of a continuing investigation of the likely ecological effects of extension of the Brisbane Airport. Other investigations related to the airport scheme and relevant to the present work have already been published or are approaching this stage. These include a study of the macrobenthos of

Bramble Bay by Stephenson, Raphael and Cook (1976) covering approximately the same period as the present work. Bramble Bay lies immediately offshore from the present sampling area and is the most relevant of the other studies, but direct comparison of results is not possible because a different sized grab (0.1 m<sup>2</sup>) was used.

In January 1974, after data had been collected

for the present work and that by Stephenson, Raphael and Cook (1976), the Brisbane region received unusually heavy rainfall which caused one of the worst floods since the area was settled (see Ward 1974). The study area was resampled after the flood, and monthly collections are continuing at two groups of sites in Serpentine Creek. The Bramble Bay project continued without interruption (Stephenson, Cook and Raphael 1977).

Another related project concerns the fish of Serpentine Creek and Serpentine Branch (Stephenson and Dredge 1976). This deals with part of the present study area, over roughly the same period, but deals with a different biota.

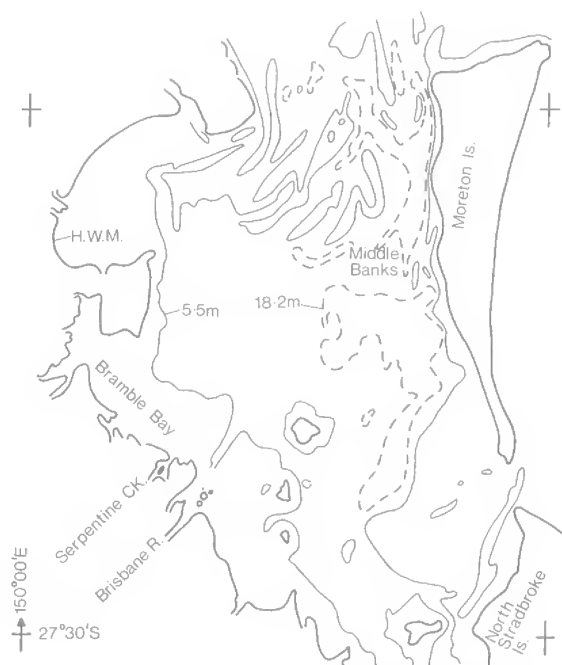


FIG. 1: Map showing localities mentioned in the text.

The present study area (see Figs. 1 and 2) would certainly be affected by major airport extension. The upper portion of Serpentine Creek and the Serpentine Branch would be filled, and input of both fresh and tidal waters to the portions that remain would be greatly reduced. Eventually the system could silt up to the point of almost complete disappearance. Meanwhile Jackson's Creek would carry the diverted drainage with increased scouring by floods and general reduction of salinities in its tidal portion.

The present analysis documents a situation which may cease to exist, and provides some basis for assessing possible changes in Jackson's Creek. The present interest is in 'average' con-

ditions, and also in the fluctuations from average during tolerably normal conditions.

#### DESCRIPTION OF STUDY AREA

Serpentine and Jackson's Creeks traverse a low-lying area north of the Brisbane River, and enter the southern portion of Bramble Bay. Freshwater drainage into Serpentine Creek is primarily from the 75 km<sup>2</sup> catchment area of Kedron Brook, which flows from the D'Aguiar Ranges to enter the south branch of Serpentine Creek via Schultz Canal, and also from surrounding airport, farming, and suburban areas which are drained by a number of constructed canals. Freshwater drainage to Jackson's Creek is from the immediately surrounding low-lying area of some 500 ha; its mouth is almost closed at low tide by a shallow bar.

Extensive intertidal sand flats line the foreshore area and the entrances to both creeks. From the mouth of the inlets to the upstream extent of the study area the banks are muddy, and lined with broad belts of mangrove flats and salt marsh. The main mangrove species is *Avicennia marina* var *australasica*, sometimes with an under-layer of *Aegiceras* or *Ceriops* and an occasional specimen of *Rhizophora*. The vegetation of this area is described by Durrington (1977), and the littoral fauna is described by Campbell, Wallace, and King (1976).

#### SAMPLING PROGRAM

Fourteen transects were chosen at right angles to one or another of the creeks. Three were on Jackson's Creek, four on the Serpentine branch and the remainder on and beyond Serpentine Creek. Three points were sampled on each transect—right bank (facing upstream), mid-stream (deepest portion) and left bank, and this gives 42 sites in all (See Fig. 2). Traverses were either marked with high visibility viscose tape or line-of-sight bearings were recorded. Site relocation errors are about  $\pm 2$  m for creek transects,  $\pm 5$  m for offshore transects. On each sampling, two catches were made with an 0.05 m<sup>2</sup> van Veen grab. Catches were sieved on board using 1 mm apertures and one sample comprises the two pooled catches.

It had been intended to sample at regular three-monthly intervals but actual collecting times were: Aug. 1972, Nov. 1972, Feb. 1973, July 1973 and Nov. 1973. These are referred to below as Times 1–5 respectively. Not all sites were sampled on each occasion and details of missing samples are given in Table 1.

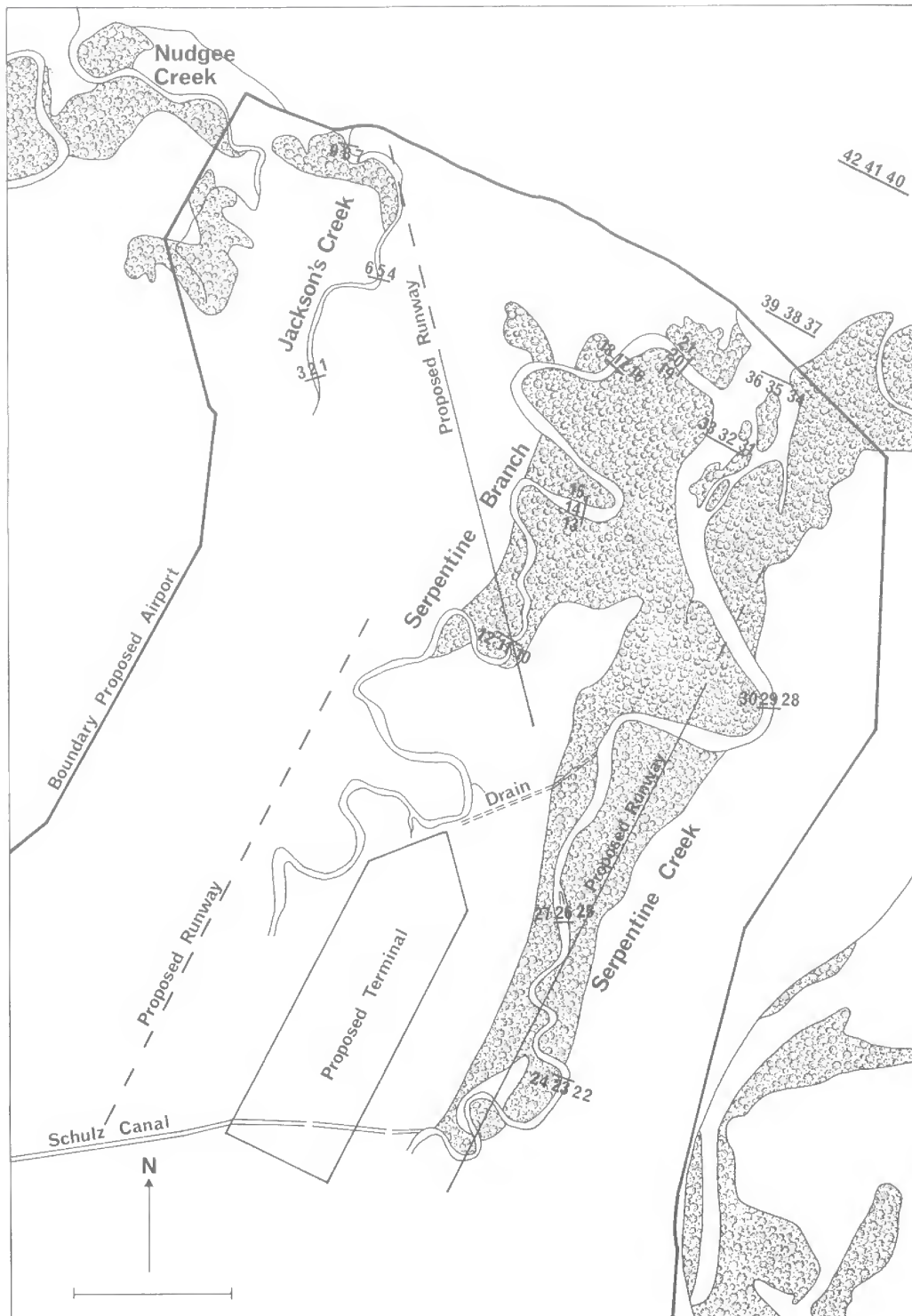


FIG. 2: Map showing the study area and sites sampled.

## ABIOTIC DATA

Information on depths, sediments, salinity and water temperature was obtained during the present survey. This has been supplemented by predicted

tidal heights from Tide Tables, Department of Harbours and Marine (1972, 1973); rainfall figures from the Commonwealth Bureau of Meteorology, Brisbane; and hydrographic data from C.S.I.R.O. Division of Oceanography and Fisheries, Cronulla.

TABLE 1: DATA ON SITES SAMPLED

Transect*	Site No.†	Missing times	Mean depth (m)	Observed sediment
Jackson's Creek				
J4	1	—	1.0	s/m
	2	—	2.0	g/s/m
	3	—	1.5	s/m
J3	4	—	1.5	s/m
	5	—	2.0	g/s/m
	6	—	1.0	s/m
J2	7	—	1.0	s
	8	—	2.5	s
	9	—	2.0	s/m
Serpentine Branch				
3B	10	1, 2, 3	2.0	s/m
	11	1, 3	2.0	s/m
	12	1, 2, 3	1.5	s/m
2B	13	—	1.5	s/m
	14	—	2.5	s/m
	15	—	1.0	s/m
1B	16	—	3.5	s/m
	17	—	4.0	g/s/m
	18	—	2.5	s/m
0B	19	1	1.0	s/m
	20	1	3.5	s/m
	21	1	1.5	m
Serpentine Creek				
4	22	2	2.0	m
	23	—	3.5	s
	24	2	1.5	m
3	25	—	1.0	s/m
	26	—	3.0	s
	27	—	2.5	s
2	28	—	2.0	s/m
	29	—	3.5	s/m
	30	—	1.0	s
1	31	—	1.5	m
	32	—	3.0	s/m
	33	—	1.0	s/m
0A	34	1	1.0	g/s/m
	35	1	3.5	g/s/m
	36	1	1.5	g/s
0C	37	1, 3, 4	1.0	g/s
	38	1, 4	2.0	g/s/m
	39	1, 4	1.5	s
0F	40	—	1.5	g/s/m
	41	4	2.0	g/s/m
	42	4, 5	1.5	s/m

\* Transect numbers are those used by Campbell et al 1976. See text for explanation of sediment symbols.

† Site numbers for each transect are listed in order: left bank, midstream, right bank (facing upstream).

DEPTHS: All sampling was at approximately high water and depths were recorded. It was impossible with tidal data available to correct these to a common datum, and in Table 1 results are given to the nearest 0.5 m. The alternative was to use data from charts produced in October 1972 for the then Commonwealth Department of Works. This might have occasioned greater inaccuracies due first to difficulties in position location on the chart and secondly to possible depth changes with time.

SEDIMENTS: Sediments from each grab were visually inspected and described in terms of m (mud), s (sand), and g (gravel, shell, wood particles). At times 1 and 2 sediments were collected and analysed for particle size distribution (see Campbell, Wallace, and King 1976). Visual estimates were reasonably compatible with analyses except that mud, as visually estimated, included not only the measured silt-clay fraction ( $< \frac{1}{16}$  mm) but also a percentage of the fine sand fraction ( $\frac{1}{4} - \frac{1}{16}$  mm). An approximate conversion of visual estimates would be: m = 10% silt + clay; m = 25% silt + clay; s = 60% sand + fine sand; s = 90% sand + fine sand; g = shell, grit, gravel, or wood particles present.

At a given site sediment descriptions changed from time to time. To some extent this could be due to inaccurate relocation of sites on a patchy substrate, but there is also an indication of change with time in that within the estuaries average sediments were predominantly sandy at time 1, muddy at time 3 and approximately equally sand and mud at times 2, 4, and 5. Average site descriptions are given in Table 1.

Certain tendencies are evident in these sediment data: (1) as might be expected the sediments in mid-stream within the estuaries are generally coarser (10/12 cases) than at either bank; (2) sediments containing grit are common at the mouth and beyond the mouth of Serpentine Creek and its branch; (3) near the mouth of Jackson's Creek and outside the mouth of Serpentine Creek the sediments are generally coarser than further upstream.

HYDROGRAPHIC AND RELATED DATA: C.S.I.R.O. Division of Oceanography and Fisheries, Cronulla, surveyed five stations within the present area of

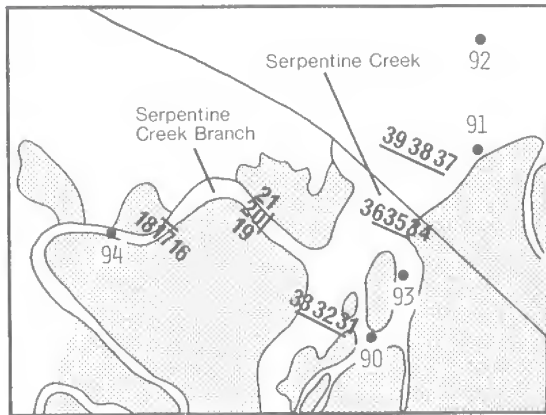


FIG. 3: Map showing hydrographic stations sampled by C.S.I.R.O. (large numerals 90-94) with our sites (bold numerals).

interest. These stations, with C.S.I.R.O. numbering 90-95 were situated as shown in Fig. 3; at each of these, at approximately fortnightly intervals, bottom water was sampled at night-time high water and depth, salinity and temperature were measured. For station 90 the data ran from 26 July 1972 to 4 May 1973, while for stations 91-94 they ran from 28 April 1972 to 4 May 1973. Data for each of these stations over the period 26 July 1972 to 4 May 1973 are given as means and variances in Table 2. One salinity value was extremely low compared with the rest, and a substitute value was used in the calculations (sta. 91; 18 Feb. 1973; 25.5‰ substituted for 15.5‰).

Table 2 shows a gradient from lowest salinity (30.2‰) and greatest variance in the uppermost station (94) to highest salinity (32.06‰) and least variance in the lowermost station (92).

Only station 94 is any appreciable distance within an estuarine system (Serpentine branch) and in tidal and temperature data this station differed

from the remainder, which were almost identical. Station 94 had the greatest tidal amplitude, and temperatures were slightly higher (0.5°C) during the period of rising temperatures from April to February.

Changes in depth, temperature, salinity, and rainfall at the Brisbane Weather Station are shown in Fig. 4. The high level of correlation ( $r = +0.86$ ) between salinity and the summated rainfall for 28 days prior to and including the day of salinity measurement is apparent (Figs. 4C, D).

Campbell, Wallace, and King (1976) recorded bottom salinities at approximately high tide at times 2-5, and temperatures at times 3-5. Results are shown in Fig. 5. Times 2, 3, and 4 show the expected salinity gradient in Serpentine Creek, Serpentine branch and Jackson's Creek. At time 5, Serpentine Creek exhibited the usual gradient but with relatively high upstream salinities; in Jackson's Creek and Serpentine branch the gradient was reversed or non-existent. Rainfall recorded at the Brisbane Weather Station for the 28 day periods prior to times 1-5 is shown in the inset to Fig. 5A.

Temperature gradients were present in the estuaries. At time 3 (Feb. 73) in Jacksons Creek upstream transects were warmer (1-2°C) than downstream transects, but within the Serpentine Creek system Serpentine branch transects were cooler than offshore transects (3°C). At time 4 (July 73) all three sets of upstream transects were cooler (2-3°C), and at time 5 (Nov. 73) all were cooler (1-2°C).

#### BIOTIC DATA

A total of 98 taxa were recognised in the collections including four which are suspected to be polyspecific. Only one quarter (23) could be identified to the specific level; this reflects the scant

TABLE 2: MEANS AND VARIANCES OF DEPTHS, TEMPERATURE AND SALINITIES AT C.S.I.R.O. HYDROGRAPHIC STATIONS, 26 JULY 1972 TO 4 MAY 1973

Stations (from upper to lower)	Depth (m)		Temp. (°C)		Salinity (‰)	
	Mean	Variance	Mean	Variance	Mean	Variance
Serpentine Branch 94	2.32	0.25	24.02	14.62	30.26	21.94
Serpentine Creek 90	0.78	0.08	23.51	12.74	31.47	11.06
93	0.92	0.07	23.69	13.16	31.55	10.40
91	1.11	0.08	23.60	13.84	31.63	9.23
92	2.13	0.15	23.60	13.84	32.06	6.79

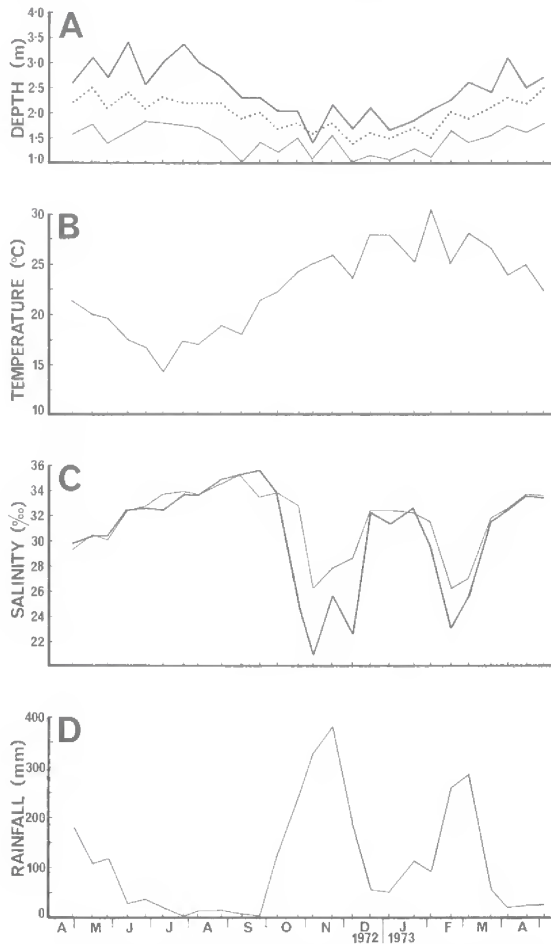


FIG. 4: Hydrographic and related data mostly from C.S.I.R.O. survey. Marks on base-line show times of sampling.

A: Depths. — = Station 94, . . . = predicted high waters at Brisbane Bar, — = mean for stations 91-93.

B: Temperatures. Mean for stations 91-94.

C: Salinities. — = means for stations 91-93, — = station 94.

D: Rainfall at Brisbane Weather Station over 28 days prior to salinity measurements.

attention which has been given in the past to estuarine benthos on the east coast of Australia. The percentages of species in major taxa were: Crustacea 46, Polychaeta 23, Bivalvia 16 and Gastropoda 14. Within the 46% for Crustacea, 19% were Decapoda and 16% Amphipoda. These percentages differ considerably from those of Bramble Bay (see Raphael 1974) in which the dominant groups with percentages were: Polychaeta 39%, Bivalvia 27% and Arthropoda 17%.

The outstanding features of the present data are the large number of amphipod species and the absence of echinoderms and tunicates.

#### ANALYSES OF DATA

The data form a three-dimensional matrix of 98 taxa ( $s$  for species)  $\times$  42 sites ( $q$  for quadrats)  $\times$  5 times ( $t$ ). The easiest way to handle such data is to summate across each dimension in turn and thus derive three two-dimensional matrices. In the present case because data are incomplete, after summation, averages must be used.

The first two-dimensional matrix we consider is derived by compressing the 98 species values to a single value and considering the  $q \times t$  matrix of 42 sites  $\times$  5 times. Actually a number of  $q \times t$  matrices are considered.

In the above analyses we consider all species, but treat them as anonymous. In the remaining main analyses we reduce the number of species under consideration (see Data Reduction below) but retain specific identities. These later analyses deal with species ( $s$ ) by sites ( $q$ ) with data averaged over times and with species ( $s$ ) by times ( $t$ ) with data averaged over sites.

#### ANALYSES OF SITES $\times$ TIMES

Direct summation of numerical recordings of all species gives the number of individuals per sample ( $N$ ), and this is the numerical equivalent of biomass. Another summation gives the number of species per sample ( $S$ ), and this is a simple measure of diversity; it is the species density in Hurlbert's (1971) terminology. A further measure of diversity was used, the standardized Shannon diversity ( $H^1$ ) (see Stephenson, Raphael, and Cook 1976). (Throughout logarithms to base 10 were employed). In the resultant three  $q \times t$  matrices containing values of  $S$ ,  $N$ , and  $H^1$  respectively, overall mean values were  $S$  7.68,  $N$  234.8 and  $H^1$  0.46. In each of the three matrices we also obtained a mean value for each site (by averaging over times, maximum number 5) and a mean value for each time (by averaging over sites, maximum number 42); ranges and variances of these means are given in Table 3.

With both  $S$  and  $H^1$  values the variance due to sites is about 6 times that due to times, while with  $N$  values the ratio is over 12 times. Variance in populations ( $N$ ) is considerably affected by occasional large values which cause skewing of the data. This is almost eliminated by the transformation  $\log_{10}(N + 1)$ : thus on the total array with raw values  $\gamma_1$  (moment coefficient of skewness) was 3.94 and  $\gamma_2$  (moment coefficient of kurtosis)

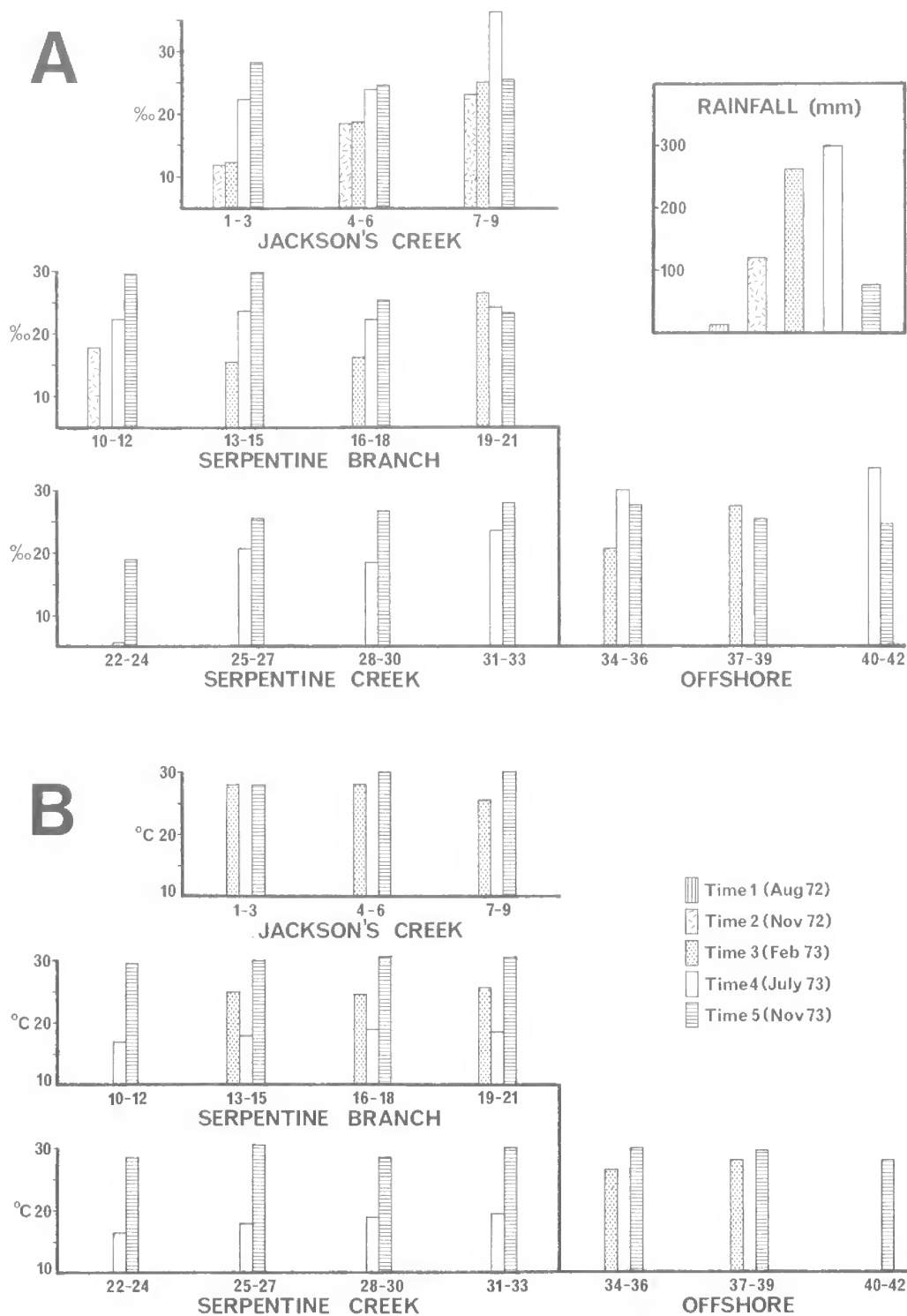


FIG. 5: Hydrographic data recorded at survey sites, times 2-5.  
 A: Salinities. Inset shows rainfall at Brisbane Weather Station over 28 days prior to times 1-5.  
 B: Temperatures.

TABLE 3: MEAN SITE VALUES AND MEAN TIME VALUES OF  $S$ ,  $N$ ,  $H^1$ , AND  $\text{LOG}_{10}(N + 1)$ 

	Sites		Times	
	Range	Variance	Range	Variance
$S$	3.2-12.3	6.33	6.50-8.63	0.919
$N$	13.2-1412.8	79938.0	105.6-315.6	6341.6
$H^1$	0.12-0.76	0.025	0.38-0.55	0.004
$\text{log}_{10}(N + 1)$	1.04-2.75	0.196	1.68-2.01	0.019

was 20.91; after transformation these became 0.21 and 2.51 respectively. Using transformed numbers the overall mean is 1.83 and variance due to sites becomes about 10 times that due to times (see Table 3).

TABLE 4: MEAN VALUES OF  $S$ ,  $\text{LOG}_{10}(N + 1)$  AND  $H^1$  FOR GROUPED SITES

Site groups	Sites	$S$	$\text{log}_{10}(N + 1)$	$H^1$
A				
Jackson's Creek	1-9	6.87	1.58	0.48
Serpentine System	10-36	7.82	1.86	0.47
B				
Serpentine Creek	22-33	6.43	1.83	0.40
Serpentine Branch	10-21	8.46	1.88	0.50

By grouping sites and comparing the mean values of  $S$ ,  $N$  and  $H$  in the groups it is possible to reveal patterns in the above data. Apart from comparisons between the main channels we defer this until after sites classification. The first comparison now considered is between sites in the two main drainage systems; Jackson's Creek and Serpentine Creek including its branch. We exclude from the latter sites 37-42 which lie beyond the mouth of the Serpentine system and thus compare sites 1-9 (Jackson's Creek) with 10-36 (Serpentine system). Results are given in Table 4(A), and while the differences are not significant, they suggest that Jackson's Creek has relatively fewer species and fewer individuals than the Serpentine system. The Shannon diversities are the same in the two systems, no doubt because the lower numbers of species and of individuals 'cancel out' in the Shannon formulation.

The second comparison is between the main portion of Serpentine Creek (sites 22-33) and the Serpentine branch (sites 10-21) excluding the shared portion (sites 34-36). Results (Table 4(B)) suggest approximately equal numbers of individuals in the two portions, but with more species and higher diversity in the Serpentine branch.

The relevant times data are given in Table 5. The lowest  $S$  and  $H^1$  values are in time 3 (February 1973) which agrees with other local results. Apart from this it is difficult to see patterns in the data, for example times 1 and 4 (August 1972 and July 1973) do not show any overall similarity and neither do times 2 and 5 (Nov. 1972, Nov. 1973). A comparable absence of seasonal patterns was noted by Stephenson, Raphael and Cook (1976) in Bramble Bay.

TABLE 5: MEAN VALUES OF  $S$ ,  $\text{LOG}_{10}(N + 1)$  AND  $H^1$  IN DIFFERENT TIMES

Times	$S$	$\text{log}_{10}(N + 1)$	$H^1$
1	8.6	2.01	0.47
2	6.7	1.68	0.48
3	6.5	1.73	0.38
4	8.4	1.82	0.55
5	7.4	1.94	0.41

#### DATA REDUCTION

For reasons stated variously elsewhere (see Clifford and Stephenson 1975) it is desirable to reduce the number of species under consideration prior to classification of the  $s \times q$  or  $s \times t$  matrices. We declare an interest in abundance and eliminate species whose abundance in the total sampling was 5 or fewer individuals.

The 53 residual species are given in the Appendix in order of abundance, and the code numbers follow this hierarchy. Subsequent reference to species is mostly by code number, sometimes accompanied by generic name.

#### PATCHINESS OF DATA

Perusal of the full data shows occasional very high values of certain species in samples. These give bias to all analyses, and already in considering the  $q \times t$  data we have effected  $\text{log}(N + 1)$  transformations. In the classifications which follow ( $s \times q$  and  $s \times t$ ) even with data transformed as above



we may expect that occasional outstanding large values will unduly influence the situation. In conceptual terms these can be regarded as showing patchiness in space and time, and there are two ways in which they can be investigated. The first is in 'precautionary' pre-classification analyses, and the second is after classification has been undertaken.

For pre-classification analyses we use the method employed by Stephenson, Raphael, and Cook (1976). The largest transformed value of a species in all samples is selected, and an analysis of variance is undertaken using this value against the remainder.  $F$  values of all species are considered and by adopting an arbitrary  $F$  value as a scale we can pinpoint the extremely patchy species and the samples in which they show outstandingly high values. Five times the  $F$  value for the 0.001 probability level is taken.

This gives the following as 'extremely patchy' species in sites  $\times$  times: 4, 5, 12, 19, 27, 24, 22, 29, 33, 31, 34, 36, 45, 38, 37, 39, 40, 42, 43, 50, 46, 48, 49, 44, 47, 52, 53. These total 28 out of 53 (leaving 25) compared with 25 out of 79 (leaving 54) in the Bramble Bay data. Clearly in the present case we are dealing with much more 'spikey' data.

The examples of space-time patchiness have no especial time concentration, but show a hint of site concentration, four examples occurring in each of the following lower estuary sites: 9, 19, 31, 35 and 38.

#### CLASSIFICATION

These consider either species ( $s$ ) by sites ( $q$ ) or species ( $s$ ) by times ( $t$ ). In both cases we use values averaged over the 'suppressed' dimension of the original matrix and transform these using  $\log_{10}(N + 1)$ . Throughout we are interested in abundance and have two main dissimilarity measures to choose from: the widely used Bray-Curtis measure (see Clifford and Stephenson 1975; Stephenson, Raphael, and Cook 1976); and the unstandardized Manhattan metric which Stephenson, Cook, and Raphael (1977) preferred for impoverished situations and for other reasons. Because the present data includes several impoverished samples the Manhattan metric is used.

Details of the classificatory technique follow those of the above authors and in brief are: (1) for entities (sites or times) Manhattan metric dissimilarity, group-average sorting; (2) for species as above but standardize by totals after transformation. Entity classifications in both cases were truncated at appropriate levels and scrutinised for possible misclassifications and subsequent re-allocations. Subjective judgement was involved in

the truncations (as outlined later), and also in whether or not to re-allocate single entities which appeared as groups; these are general problems of the group-average sorting strategy.

As obtained by the method outlined, species groups were not of great conceptual value. The main reason is that, after standardizing by totals, the less common species have a major role in species classification and yet they occur in such low numbers (and often in such patchy fashion) as to show scant relationship to the entity-groups. If we restrict our interest to those species that characterize entity-groups in a quantified fashion, we eliminate most of the species in the matrix. In the present case this 'wrecks' the species classification produced by the computer, but so few species remain that visual classification is adequate.

Species reduction at this second stage (the first stage was the elimination of species with a total abundance of 5 or fewer) was in two steps. We first eliminated species which did not attain an average population of 1.0 individuals in any of the site-groups under consideration. These comprised the species lowest in the abundance hierarchy and a few at slightly higher levels which approximated to an even spread over the site-groups. In the second step we looked for 'noticeable' differences between recordings in the site-groups taking cognisance of mean values in site-groups and also their variances. As outlined in previous papers (Stephenson and Dredge 1976; Stephenson, Raphael and Cook 1976) there are problems in this procedure. We have used the mechanics of the  $F$  test because the outcomes relate closely to those obtained by visual scanning of data. Although we employed  $\log_{10}(N + 1)$  transformations of the data to remove the worst of the skewness we appreciate that, because we have classified the data, we have destroyed its randomness and thus the rationale for legitimate use of the test. Hence we refer to this as the 'pseudo  $F$  test' and speak of 'noticeable' differences and not 'significant' ones. Transformed values of species recordings were tested using various combinations of site-groups, and usually one site-group against the others. Species were eliminated if the pseudo  $F$  value was less than the  $F$  value giving 0.05 probability; the residual species hence conform to the site-groups in the terminology of Stephenson, Williams and Cook (1974).

ANALYSES OF SPECIES  $\times$  SITES: Results of the classification of sites is shown as a dendrogram in Fig. 6. At the 10 Manhattan unit dissimilarity level there are six groups of very unequal sizes, labelled A-F on the dendrogram base. We consider these in

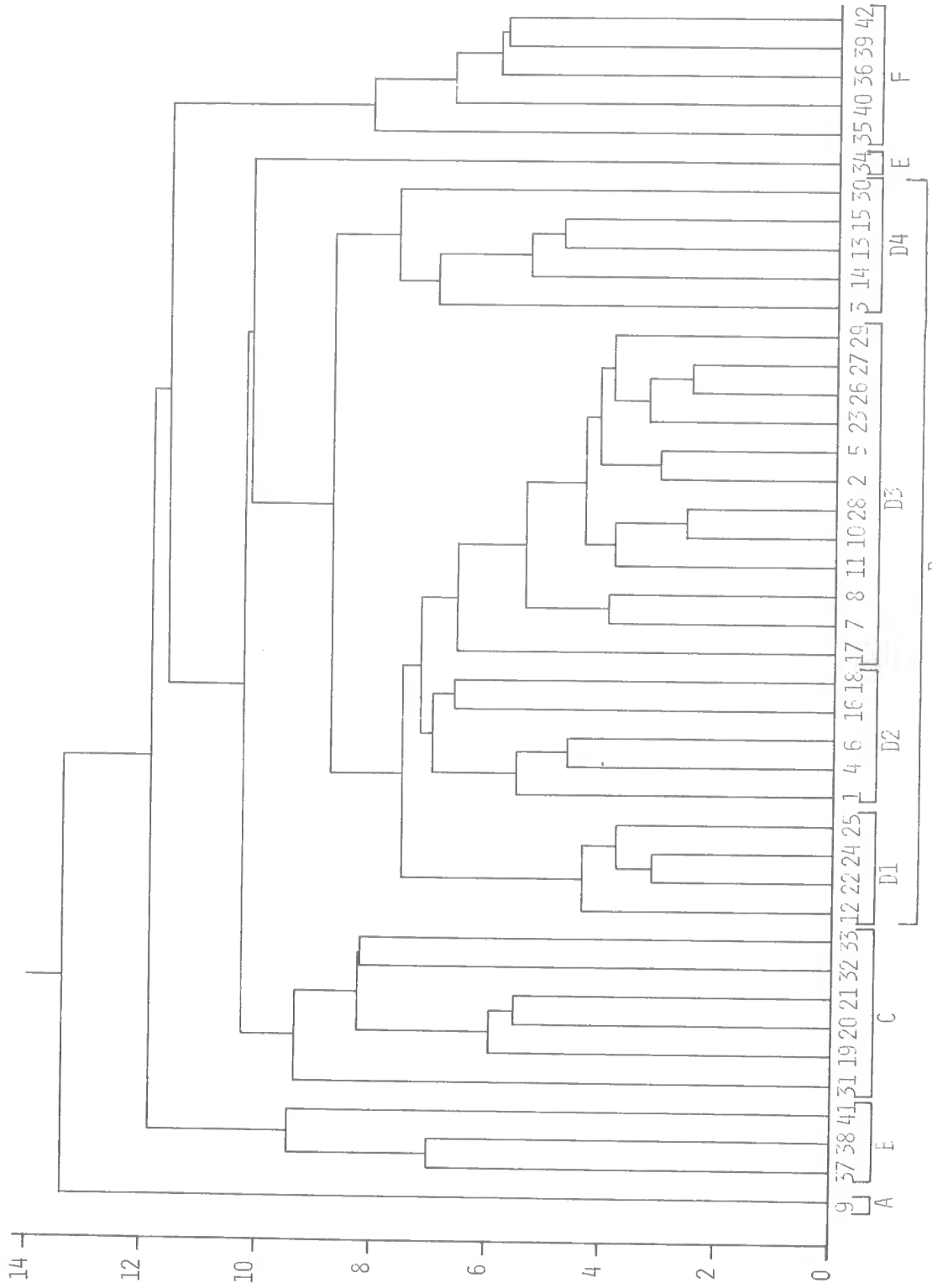


FIG. 6: Dendrogram of site-groups, Manhattan metric dissimilarity  $\log_{10}(N + 1)$  data.

the first instance, and deal later with the subdivisions of the largest site-group (D).

Two of the site-groups consist of single sites: site-group A (site 9) and site-group E (site 35). Both are difficult to reallocate to any of the remaining groups. Site 9, near the base of a steep eroding muddy bank at the mouth of Jackson's Creek, is characterized by the following species: 3 (*Xenophthalmus*), 7 (*Laonice*), 15 (*Grandidierella*) and 4 (*Corophium* sp. 1). Of these, two (spp. 7 and 15) were previously noted as showing extreme patchiness in site 9. Site 34, a similar situation at the mouth of the Serpentine Creek system, is mostly characterized by species 7 (*Laonice*).

The species conforming to the main site-groups (B, C, D and F) were arranged in species-groups and the two-way table is given in Table 6. It is evident that the species-groups characterize the site-groups in a clearly interpretable manner. Conversely the site-groups can be described as

'communities' in terms of their commonest characterizing species, but because of chronological variations some qualifications are needed as indicated below.

The site-groups show topographic and sedimentary coherence (see Fig. 7). Site groups B (sites 37, 38, 41) and F (sites 35, 36, 39, 40, 42) at or beyond the mouth of the Serpentine system have predominantly grit and sandy sediments. *Spisula* is abundant in both groups. *Xenophthalmus* was common in sites 35 and 36 of area F at time 5; *Urohaustorius*, *Mysella* and acteonid also characterize this area. Area B is characterized by *Corophium*, *Paracorophium*, *Gammaropsis* and *Melita*, but abundance of these varied greatly from time to time. When collection sites were accurately relocated in or near mid-stream these species were most abundant, and site group B is seen as a mid-stream outside group. Sediments were, on average, finer than those of site group F.

TABLE 6: CONFORMING SPECIES (ARRANGED IN SPECIES-GROUPS) CHARACTERIZING THE MAIN SITE-GROUPS WITH MEAN NUMBERS PER SAMPLE IN THE SITE-GROUPS

Species group	Species (code no.)	Site Groups			
		B	C	D	F
I (most in B)	<i>Corophium</i> (4)	130.7	0	0.1	0.5
	<i>Paracorophium</i> (5)	77.7	0	0.4	0.1
	<i>Grandidierella</i> (15)	7.0	0.2	0.8	3.0
	<i>Gammaropsis</i> (19)	8.8	0	0.2	0
	<i>Melita</i> (29)	3.5	0	0	0
II (most in C)	<i>Xenophthalmus</i> (3)	0	53.4	0.2	11.5
	<i>Laonice</i> (7)	0	3.9	1.4	0.1
	<i>Sanguinolaria</i> (10)	0	9.7	1.4	1.8
	capitellid (11)	0.4	6.8	1.7	1.1
	<i>Owenia</i> (12)	0	8.2	0.1	0.2
	<i>Armandia</i> (23)	0	1.0	0.3	0
	<i>Tellina</i> (25)	0	1.5	0.1	0
	<i>Lumbrinereis</i> (28)	0.1	1.2	0	0.4
III (most in D)	<i>Apseudes</i> (1)	0	59.5	170.2	0.2
	<i>Eriopisa</i> (8)	0	1.7	5.5	0.2
	<i>Haploscoloplos</i> (9)	0	0.2	4.1	0
	<i>Arthritica</i> (17)	0	0	2.2	0
	<i>Ceratonereis</i> (18)	0.1	0.4	1.3	0.2
IV (most in F)	<i>Urohaustorius</i> (13)	0	0	0.8	9.5
	acteonid (14)	1.2	3.4	0	5.5
	<i>Mysella</i> (16)	0.5	1.3	0.2	6.6
V (co-equal B and F)	<i>Spisula</i> (2)	265.5	9.6	6.2	294.3

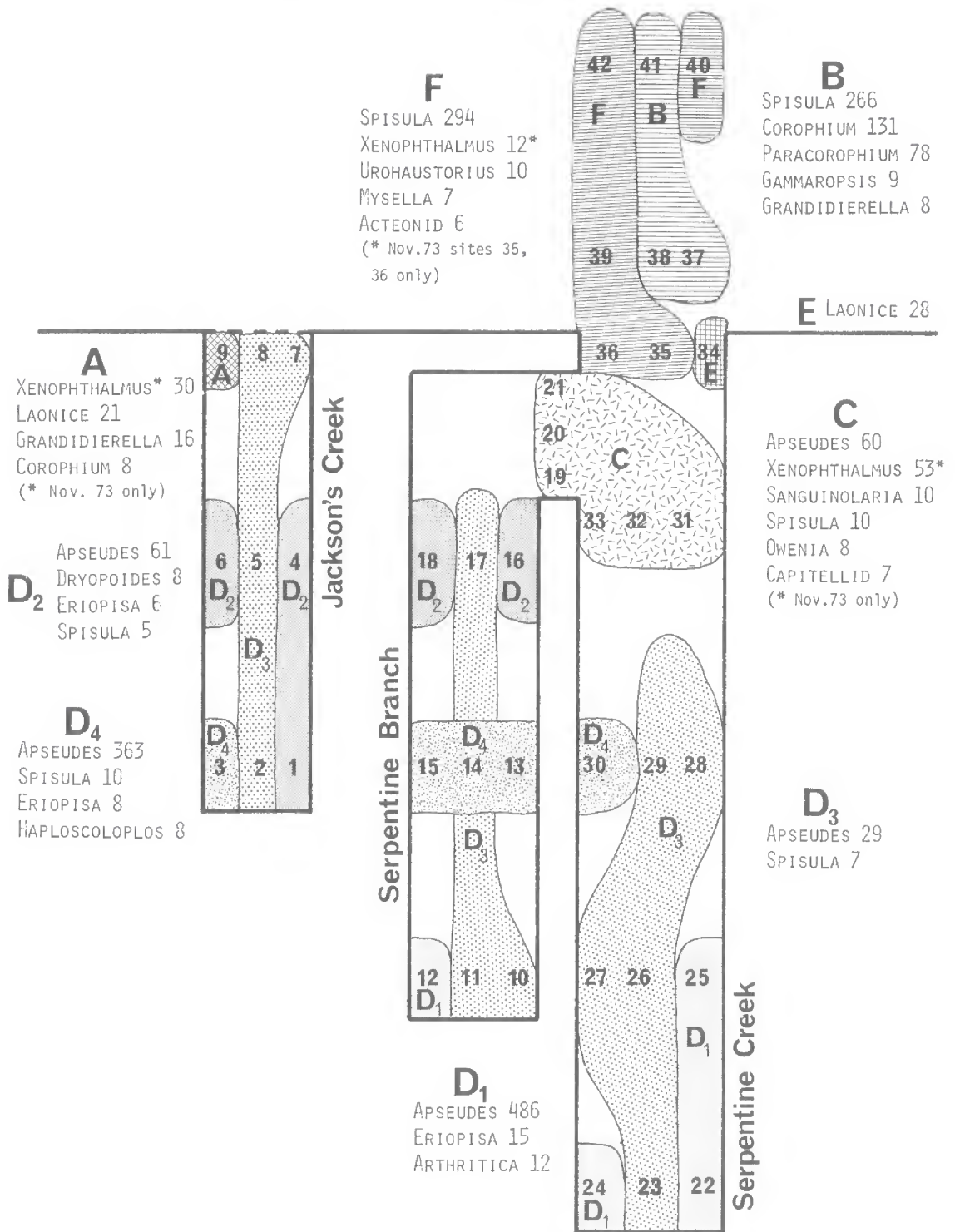


Fig. 7: Schematic diagram of survey area showing site groups and abundance of commoner species ( $n > 4$ ) in each site group.

TABLE 7: CONFORMING SPECIES (ARRANGED IN SPECIES GROUPS) CHARACTERIZING THE SUBORDINATE SITE-GROUPS D1-D4, WITH MEAN NUMBERS PER SAMPLE IN THE SITE-GROUPS

Species group	Species (code no.)	Site-Groups			
		D1	D2	D3	D4
(i) (most in D1)	<i>Arthritica</i> (17)	12.0	0	0.6	0.2
	<i>Diala</i> (40)	1.4	0	0	0
(ii) (most in D3)	<i>Sanguinolaria</i> (10)	0	0.3	2.7	0.6
(iii) (most in D4)	<i>Grandidierella</i> (15)	0	0.2	0	4.3
	<i>Ceratonereis</i> (18)	1.5	1.0	0.7	3.0
	<i>Laternula</i> (20)	0.1	0.5	0.1	1.5
	<i>Australonereis</i> (21)	0	0.1	0.2	1.7
	sabellid (22)	0.2	0.7	0.1	1.6
(iv) (almost coequal most D1 and D4)	<i>Apsuedes</i> (1)	486.4	61.2	29.1	363.2
(v) (least in D1)	<i>Spisula</i> (2)	0.2	4.7	7.1	10.4
	<i>Dryopoides</i> (16)	0.2	7.7	3.0	6.6
	<i>Laonice</i> (7)	0.2	3.4	1.1	1.0
	<i>Haploscoloplos</i> (9)	0.1	4.6	2.7	8.2
(vi) (least in D3)	<i>Eriopisa</i> (8)	14.5	5.9	1.3	8.1
	capitellid (11)	2.5	2.2	0.3	3.8

Site group C (sites 19-21, 31-33, lies just inside the mouth of the Serpentine Creek system, where sediments are variable but mostly muddy. It is characterized by the occasional occurrence of *Xenophthalmus* in large numbers (time 5 only,  $N = 186$ ) and the remaining species of group II. *Apsuedes* is common ( $N = 59.5$ ) but not as abundant as in group D. Site group C has no counterpart in Jackson's Creek, possibly because of the smaller size of that creek and because its mouth is largely closed by a shallow sand bar.

Site group D contains 27 sites, comprises all of the 'within estuary' sites, and can be resolved into four subordinate site-groups shown as D1, D2, D3 and D4 on the base of Fig. 6. The species characterizing these site-groups are arranged in species-groups in Table 7. There are possible ambiguities in this arrangement, for example species-groups (iv) and (vi) have much in common.

All the subordinate site-groups are dominated by *Apsuedes* (sp. 1), but the mean numbers per sample are different and the dominance is most

marked in D1 and D4. The subordinate species are different in each case. In D1 they are *Eriopisa* (sp. 8) and *Arthritica* (sp. 17), in D2 they are *Dryopoides* (sp. 6) and *Eriopisa* (sp. 8), in D3 *Spisula* (sp. 2) and in D4 *Spisula* (sp. 2), *Haploscoloplos* (sp. 9) and *Eriopisa* (sp. 8). Site-group D4 is positively characterized by the largest number of species (five) and site-group D1 negatively characterized by the largest number (four).

The subordinate site-groups again show topographic coherence (Fig. 7). *Site-group D1* comprises sites 12, 22, 24 and 25. These are on the upper traverses of Serpentine branch and Serpentine Creek and all are bank sites with depths of 1-2 m and sediments exclusively or predominantly of mud. *Site-group D4* comprises sites 3, 13, 14, 15, 30. These are in the middle traverses of Serpentine Branch and Serpentine Creek and the upper traverse of Jackson's Creek. All are bank sites except 14, which is the mid point of a traverse where the stream was broad, slow flowing, with almost uniform depth and sediment throughout its width.

*Site-group D2* comprises sites 1, 4, 6, 16 and 18. These are restricted to Jackson's Creek and the Serpentine branch, and all are bank sites at approximately similar distances from the coastline. The sediments are either sand and mud or sandy mud: *Site-group D3* comprises sites 2, 5, 7, 8, 10, 11, 17, 23, 26, 27, 28 and 29. These are widely distributed throughout the length of the estuarine portions of the sampling area. Most are midstream sites (2, 5, 8, 11, 17, 23, 26 and 29). Of the remainder, 27 although nearest the bank is the deepest site on its transect and represents maximum stream flow; 28, on the outward sweep of the creek is also well within the main stream flow; 10 is a deep bank site in a narrow portion of the creek; and 7 is a very sandy site near the mouth of Jackson's Creek which would also be subject to some stream action. Except for site 28 the sediments are predominantly sandy.

In summary then, excluding the two aberrant sites at the mouths of Jackson's and Serpentine Creeks, the site groups recognised are:

- (a) Outside, away from main stream bed (F)
- (b) Outside, within main stream bed (B)
- (c) Mouth (C)
- (d) Estuarine within main stream bed, eroding substrate (D3)
- (e, f, g) Estuarine away from main stream bed, depositing substrate, which is divided into three sections, upper estuary (D1); mid estuary (D4) and lower estuary (D2).

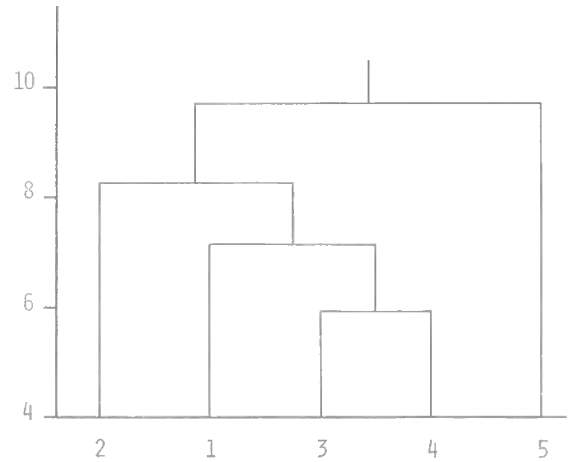


FIG. 8: Dendrogram of time-groups, Manhattan metric dissimilarity  $\log_{10}(N+1)$  data.

ANALYSES OF SPECIES  $\times$  TIMES: Using data averaged over all sites, the result of the classification of times is shown on Fig. 8. There is no close grouping of the comparable seasons viz. times 1 and 4, and times 2 and 5, and the closest grouping of times 3 and 4 is sequential. This tendency for sequential rather than seasonal groupings was noted by Stephenson, Raphael and Cook (1976) in their work at Bramble Bay over roughly the same period.

Times were grouped in almost every possible combination to obtain conforming species but

TABLE 8: CONFORMING SPECIES (ARRANGED IN SPECIES-GROUPS) CHARACTERIZING TIMES, WITH MEAN NUMBERS PER SITE AT EACH TIME

Species group	Species (code no.)	TIME				
		2	1	3	4	5
I (most in times 2 and 1)	<i>Paracorophium</i> (5)	14.8	5.3	0	1.5	0
	<i>Haploscoloplos</i> (9)	3.0	9.0	1.5	2.2	1.5
	<i>Gammaropsis</i> (19)	0.6	3.0	0	0	0
II (most in time 4)	<i>Xenophthalmus</i> (3)	0	0	0.3	0	38.8
	<i>Owenia</i> (12)	0.1	0.1	0.1	0.1	5.9
	acteonid (14)	0	0	0.6	0.3	4.0
III (least in time 2)	<i>Aapseudes</i> (1)	30.6	124.3	250.2	124.3	78.4
	<i>Spisula</i> (2)	14.8	49.1	19.0	78.4	157.3
IV (least in time 1)	<i>Laonice</i> (7)	6.9	0	3.0	1.5	2.2
V (least in time 3)	<i>Dryopoides</i> (6)	2.2	9.0	0	6.9	2.2

without noticeable success. Hence times are taken as separate entities. In Table 8 they are listed in dendrogram order and the conforming species are arranged in species-groups. Only two of the species listed give any indication of seasonal repetition and these are *Apseudes*, species 1 (low in times 2 and 5) and *Dryopoides*, species 6 (high in times 1 and 4).

**RELATIONSHIP OF  $q \times t$  DATA TO  $s \times q$  DATA:** Having derived site-groups by considering their specific components, we now compare the following within the different 'communities'—average number of species per sample ( $S$ ), average population of all species per sample ( $N$ ), and average individual Shannon diversity per sample ( $H^1$ ). The equivalent exercise on time-groups is not pursued because clear time-groups are not apparent in the data.

TABLE 9: MEAN VALUES PER SAMPLE OF  $S$ ,  $N$  AND  $H^1$  IN SITE-GROUPS (EXCLUDING THOSE OF SINGLE SITES)

Site group	Sites in Site-group	$S$ Value	$N$ Value	$H^1$ Value
B	37, 38, 41	5.7	485.9	0.34
C	19, 20, 21, 31, 32, 33	10.3	172.1	0.62
D1	12, 22, 24, 25	5.2	516.3	0.20
D2	1, 4, 6, 16, 18	8.3	101.8	0.53
D3	2, 5, 7, 8, 10, 11, 17, 23, 26, 27, 28, 29	5.0	53.4	0.45
D4	3, 13, 14, 15, 30	8.2	416.6	0.42
F	35, 36, 40, 42	8.0	372.7	0.42

The relevant data contained in Table 9, show a significant negative correlation ( $-0.83$ ) between  $N$  and  $H^1$  using the Spearman rank correlation coefficient.

Site-group D3 is noteworthy in having the lowest sample populations and the fewest species. Site-group D1 is also noteworthy with the highest sample populations, almost as few species, and the lowest diversity. Site-group C has the highest diversity and most species.

## DISCUSSION

The main purpose of the present work was to analyse data which attempted to document a situation which is likely to disappear. There were some shortcomings in the information available to us, particularly in relation to abiotic data. To have obtained adequate data upon depths and sediments in this labile habitat would have required more extensive topographic and sedimentary surveys than were possible with resources available. The

existing sediment data show the expected differences between sites with generally coarser sediments in midstream than near the banks and again as one moves downstream. The hydrographic data indicate that at the sites furthest offshore in the present survey there was a temperature range of ca 14.3°C to 30.4°C and a salinity range of ca 26‰ to 35‰; of the sites furthest upstream there was a temperature range of ca 14°C to 30°C and a salinity range of ca 6‰ to 27‰, with salinity closely dependent upon the rainfall of the previous month.

The temporal variation in abiotic data recorded at each site should be stressed. Changes in salinity, depth, sediment, and temperature were so great that often the only common attribute of a given site at time  $x$  and the same site at any other time was its geographical location.

Knowledge of the specific composition of the biota is also noteworthy incomplete. This again reflects the general absence of comparable studies in the benthos of the smaller estuarine systems on the eastern coast of Australia. The only relevant work available prior to the present survey was a study of the dredged macrobenthos near the mouth of the Brisbane River (Hailstone 1972). Again the species list was incomplete. Since then Campbell *et al.* (1974) have given a preliminary report on the benthos in nine estuaries in south-eastern Queensland, using similar techniques to those in the present work. Again most of the biota was not identified to the specific level. More recently Boesch (MS) has given a preliminary account of his 1972–73 study of 10 sites extending nearly 70 km upstream from the mouth of the Brisbane River; again identifications are incomplete.

The number of taxa obtained in the present study (98) is about half the number obtained by Raphael (1974) in Bramble Bay, but is about half as many again as the 64 which Campbell *et al.* (1974) obtained in nine local estuaries. It should be noted that this last survey was carried out some while after the devastating floods of January 1974. Stephenson, Cook and Newlands (MS), with somewhat more intensive collecting, obtained ca 450 species in the Middle Banks region of Moreton Bay, and roughly the same number were obtained by Stephenson, Williams and Cook (1972) south of Peel Island in Moreton Bay.

In all the local benthic surveys made by a grab, data have been skewed due to occasional occurrences of very high recordings of many of the species, and this has been allowed for in part by transforming the data using  $\log(N + 1)$ . Following Stephenson, Raphael and Cook's (1976) 'patchiness' technique, extremely high recordings of

species in their sites  $\times$  times occurrences were isolated. The proportion of these 'patchy' species is considerably greater in the present study (28/53) than that in Bramble Bay (25/79).

Turning to broader issues, if we exclude purely faunistic collecting the underlying purpose of macrobenthic sampling is to reveal trends, patterns, or groupings within the data. The scale of patterns which is revealed will depend upon the scale of the sampling. Thus within Moreton Bay and using approximately square grids Poiner (1974) has shown site-groups in benthic samples taken at 6 m apart in work north of Peel Island; Stephenson, Williams and Cook (1974) working south of Peel Island showed groups in sites ca 0.5 km apart; while Stephenson, Raphael and Cook (1976) obtained them in Bramble Bay with sites ca 1 km apart. In the present work there were two scales of sampling, with transects ca 1 km apart aimed at longitudinal (upstream-downstream) patterns and at distances from ca 10 to 100 m apart aimed at transverse (cross-river) patterns. The site-groups which were obtained (Fig. 7) show that purely longitudinal sampling would not have been adequate in the present situation.

Although it might be considered inadvisable to average species  $\times$  sites data over all times when dealing with such a labile habitat as an estuary, particularly in the present instance where only 5 times were available, our justification for having done this can be found in the results. The site-groups that were generated appear conceptually sound in relation to topography and average abiotic parameters.

We have recognized seven site-groups in the present study and clearly each occupies a relatively small area. As indicated this may partially reflect original preconceptions as revealed by the spatial aspects of the sampling programme, but this is not the entire picture. The spacing of sites produced topographic sense and this justifies the preconceptions; however the relative absence of chronological sense in the data contradicts the temporal preconceptions regarding the area.

It appears that patchiness in the data has gone close to making meaningless the times  $\times$  species classification. Present results show negligible seasonal repetition in the biota and little similarity between consecutive times. These conclusions agree with the general tendencies, albeit better documented, which Stephenson, Raphael and Cook (1976) obtained in Bramble Bay. The present results suggest, in general, that there were insufficient times collected and that the intervals between samplings were too long to produce a meaningful classification of times  $\times$  species data.

Selected sites in Serpentine Creek are currently being sampled on a more frequent basis.

Reverting to the spatial situation, we suggest that the small scale topographical patterns are a real phenomenon. Elsewhere it has been hinted that subtropical benthos may have smaller scale area patterning than that of temperate habitats (Stephenson, Williams and Cook 1974; Clifford and Stephenson 1975). It seems that the present patterns are an estuarine manifestation of this phenomenon.

The study closest to the present in locale and general approach was that of Boesch (MS) who investigated the macrobenthos of the Brisbane River for almost a year beginning in 1972. Only near-bank sites were sampled, and at distances of ca 6 km apart. While this sampling strategy involved ten samplings along the length of the estuary against a maximum of seven in the present case, it is clear that small scale patterns would not be revealed. Boesch's numerical approach differed from our own and he rejected site-groupings. The rationale for considering groupings of data has been detailed at length elsewhere (Clifford and Stephenson 1975).

General concepts from estuarine literature suggest that in estuaries populations are high, but diversities are low. It is true that certain of the extreme upper estuarine sites form a site-group (D1, sites 12, 22, 24, 25) with the highest populations obtained in the survey and with the fewest species and lowest standardized Shannon diversity. We presume that the stress factors here are associated with periodic dilution. The next most populous and least diverse site-group is B (sites 37, 38, 41) in the lowest portion of the estuary. We presume that here the stress factors are associated with tidal scour. In general the middle estuary has lower populations, and higher diversities than noted above, but within this area the site-groups show no clear relationships between populations, diversities and topography.

From our early analyses we suggest one important relationship between these three aspects: the Serpentine system as a whole is more populous than Jackson's Creek. If the former is filled in, it will be of interest to determine whether the latter will retain even its present low populations when additional freshwater drainage is diverted into it.

In terms of time, lowest populations were in time 2 (Nov. 1972) and highest in time 3 (Feb. 1973). Both coincide with periods of salinity reduction and hence there is no easy 'explanation' of the results. It should be noted that both are also approximately the inverse of the situation in the more open waters of Moreton Bay (see for example



Stephenson, Williams and Cook, 1974). Until fuller data on time changes are available further discussion of these data is premature.

In the recent benthic literature there are attempts to place species in a single ecological category. The work of Grassle and Grassle (1974) gives excellent examples and categorizations of opportunistic species, and Boesch (MS) uses the following descriptive terms: stenohaline marine, euryhaline marine, euryhaline opportunist, and estuarine endemic. Local work upon *Spisula*, one of the common species in the present survey, suggests that simple categorization is an oversimplification. *Spisula* is often an abundant species in the shallower waters of Bramble Bay (Stephenson, Raphael and Cook 1976) and forms a *Spisula* 'community'. Based on this it could be described as 'euryhaline marine (shallow water)'. Because it does not conform to time in the present survey (see Table 8) it could be described as 'estuarine endemic'. Because after the severe flood of early 1974 it dominated extensive areas of Bramble Bay (Stephenson, Cook and Raphael 1977), as regards the postflood situation it would become 'euryhaline opportunistic'.

Most of the descriptive terms in current use derive from experience of temperate macrobenthos. Past studies in Moreton Bay show that virtually all the commoner species show marked fluctuations in numbers, with both seasonal and annual components (Stephenson, Williams and Cook 1974; Stephenson, Raphael and Cook 1976). The same is true in unpublished studies of the Middle Banks region of Moreton Bay, which is relatively uninfluenced by near-land changes (Stephenson, Cook and Newlands MS). When the biotas of non-estuarine situations approximate to being in a state of flux, it is difficult to relate estuarine species to any non-estuarine basis. If simple descriptive terms are required, the single term 'transient' covers almost all cases.

On a species by species basis there are certain similarities between Boesch's (MS) work and our own, and certain differences. Boesch describes *Apseudes* as an estuarine endemic and it is the dominant species in all our site-groups except those within or close to Bramble Bay. In our work it

showed marked temporal changes, (see Table 8) but apparently did not in Boesch's. Boesch included *Grandidierella* as a dominant estuarine endemic but in our work it was concentrated in the lower estuarine sites and never dominant. Similarly *Ceratonereis* in our study was never dominant and characterized only a small mid-estuarine site-group. *Marphysa* and *Notomastus* were listed by Boesch as estuarine endemics but are equally non-estuarine endemics, both occurring in Bramble Bay, with the former common on foreshores at Stradbroke Island (Stephenson 1967) and the latter common in the deeper waters of Moreton Bay (Stephenson, Cook and Newlands MS). Two other species listed by Boesch as dominants from the Brisbane River (*Owenia* and *Prionospio*) also extend widely to the Middle Banks area of Moreton Bay (Stephenson, Cook and Newlands MS).

In the present work the closest approximation to an euryhaline opportunist is *Xenopthalmus* which is a transient dominant or co-dominant in the lower estuary (site-groups A and C) and less of a transient co-dominant in the shallower waters of Bramble Bay (Stephenson, Raphael and Cook 1976). It was not listed by Boesch (MS) amongst his 37 most frequent species.

#### ACKNOWLEDGMENTS

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## APPENDIX

Species from Serpentine Creek benthos with indications of their systematic positions. Only SPECIES WITH  $\geq 5$  individuals are listed; code numbers are in hierarchical order of abundance.

Code No.	Species		No. of individuals collected
1	<i>Apseudes estuarius</i> Boesch	(Tanaidacea, Apseudidae)	21293
2	<i>Spisula trigonella</i> Lamarck	(Bivalvia, Mactridae)	11962
3	<i>Xenopthalmus pinnotheroides</i> White	(Decapoda, Pinnotheridae)	1662
4	<i>Corophium</i> sp. 1	(Amphipoda, Corophiidae)	1266
5	<i>Paracorophium</i> sp.	(Amphipoda, Corophiidae)	781
6	<i>Dryopoides</i> sp.	(Amphipoda, Corophiidae)	711
7	<i>Laonice</i> sp.	(Polychaeta, Spionidae)	688
8	<i>Eriopisa</i> sp.	(Amphipoda, Gammaridae)	675
9	<i>Haploscoloplos</i> sp.	(Polychaeta, Orbiniidae)	606
10	<i>Sanquinolaria donacioides</i> (Reeve)	(Bivalvia, Gariidae)	482
11	capitellid	(Polychaeta, Capitellidae)	457
12	<i>Owenia fusiformis</i> Delle Chiaje	(Polychaeta, Oweniidae)	289
13	<i>Urohaustorius</i> sp.	(Amphipoda, Haustoriidae)	286
14	acteonid	(Gastropoda, Acteonidae)	222
15	<i>Grandidierella</i> sp.	(Amphipoda, Corophiidae)	216
16	<i>Mysella</i> sp.	(Bivalvia, Montacutidae)	202
17	<i>Arthritica helmsi</i> (Hedley)	(Bivalvia, Erycinidae)	193
18	<i>Ceratonereis erythraeensis</i> Fauvel	(Polychaeta, Nereidae)	180
19	<i>Gammaropsis</i> sp.	(Amphipoda, Isacidae)	105
20	<i>Laternula tasmanica</i> (Reeve)	(Bivalvia, Laternulidae)	103
21	<i>Australonereis ehlersi</i> (Augener)	(Polychaeta, Nereidae)	78
22	sabellid	(Polychaeta, Sabellidae)	72
23	<i>Armandia</i> sp.	(Polychaeta, Opheliidae)	63
24	<i>Polinices</i> sp.	(Gastropoda, Naticidae)	63
25	<i>Tellina cf. deltoidalis</i> Lamarck	(Bivalvia, Tellinidae)	61
26	<i>Paraphoxus</i> sp.	(Amphipoda, Phoxocephalidae)	56
27	<i>Nassarius ellana</i> (Iredale)	(Gastropoda, Nassariidae)	51
28	<i>Lumbrineris</i> sp.	(Polychaeta, Eunicidae)	51
29	<i>Melita</i> sp.	(Amphipoda, Gammaridae)	42
30	<i>Sergestes</i> sp. ? spp.	(Decapoda, Sergestidae)	34
31	<i>Mesanthura</i>	(Isopoda, Anthuridae)	32
32	peneid sp. ? spp.	(Decapoda, Peneidae)	30
33	<i>Ilyograpsus</i> sp.	(Decapoda, Grapsidae)	26
34	<i>Macrophthalmus</i> sp. ? spp.	(Decapoda, Ocypodidae)	24
35	<i>Nephtys australiensis</i> Fauchard	(Polychaeta, Nephtyidae)	22
36	nereid	(Polychaeta, Nereidae)	21
37	<i>Acteocina fusiformis</i> (Adams)	(Gastropoda, Acteonidae)	20
38	<i>Cerceis</i> sp. ? spp.	(Isopoda, Sphaeromidae)	18
39	<i>Marphysa</i> sp.	(Polychaeta, Eunicidae)	16
40	<i>Diala</i> sp.	(Gastropoda, Cerithiidae)	16
41	<i>Magelona</i> sp.	(Polychaeta, Magelonidae)	16
42	<i>Westwoodilla</i> sp.	(Amphipoda, Oedicerotidae)	14
43	spionid 2	(Polychaeta, Spionidae)	13
44	oedicerotid	(Amphipoda, Oedicerotidae)	10
45	<i>Modiolus</i> sp.	(Bivalvia, Mytilidae)	9
46	dexaminid	(Amphipod, Dexaminidae)	9
47	polychaete 1	(Polychaeta)	9
48	<i>Ringicula</i> sp.	(Gastropoda, Ringiculidae)	8
49	rissoinacean	(Gastropoda)	8
50	epitonid	(Gastropoda, Epitoniidae)	6
51	mesodermatid	(Bivalvia, Mesodermatidae)	6
52	<i>Corophium</i> sp. 2	(Amphipoda, Corophiidae)	6
53	<i>Callanaitis</i> sp.	(Bivalvia, Veneridae)	6

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